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SATELLITE VEHICLE WASTE COLLECTION SYSTEMS

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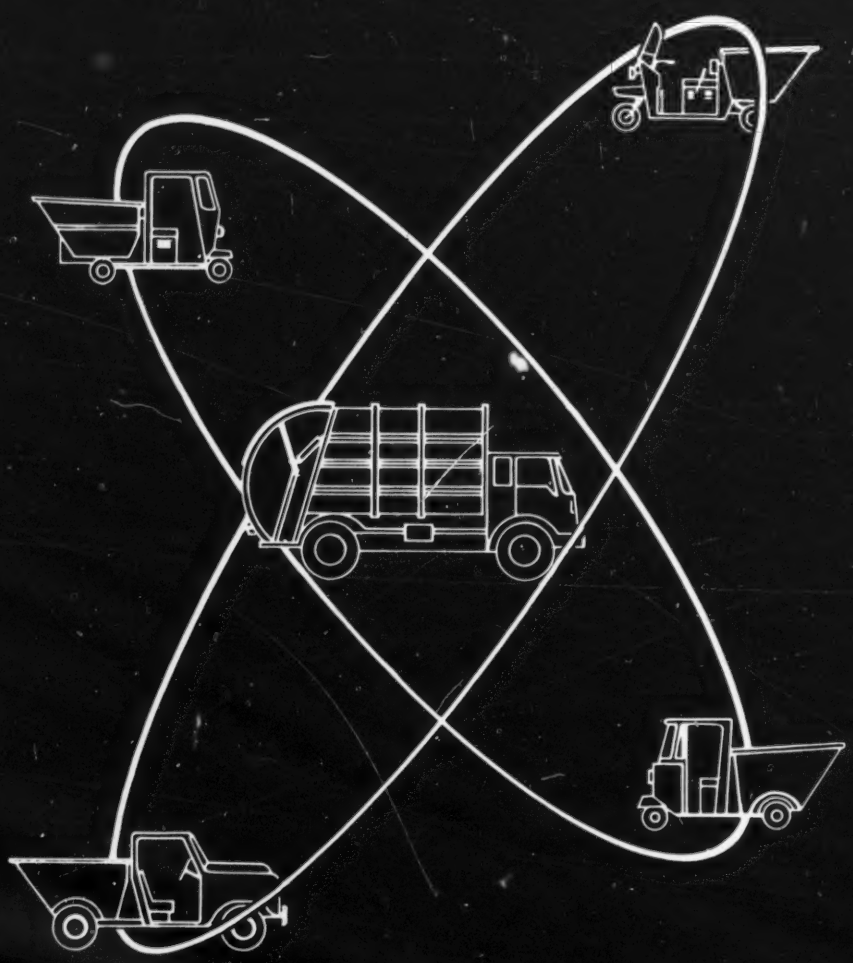
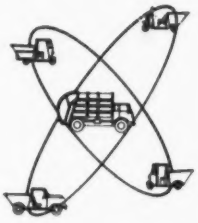


Satellite Vehicle Waste Collection Systems

This summary (SW-82ts. 1) of a comprehensive report by Ronald A. Perkins was prepared by JAMES E. DELANEY



U.S. ENVIRONMENTAL PROTECTION AGENCY

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FOREWORD

IN THE MAIN, current solid waste collection practices do not differ significantly from those used at the turn of the century. The horsedrawn cart has merely been replaced by a motor-powered van having a larger capacity and a compaction capability. This lag in the development of new technologies has had a marked economic impact, because it costs four times as much to collect residential solid wastes as it does to dispose of them. Ways must be found, therefore, to maximize efficiency while minimizing costs.

This report summarizes the findings derived from an in-depth study of a comparatively new technique being used to collect residential solid wastes. The system's operational details are presented and compared to more conventional methods. The relative efficiencies achieved by private and municipal operators are also outlined.

If, after finishing this summary, the reader decides the technique might have application in his particular situation, a wealth of statistical information and numerous mathematical models are available in a separate publication.

— SAMUEL HALE, JR.
Deputy Assistant Administrator
for Solid Waste Management

SATELLITE VEHICLE WASTE COLLECTION SYSTEMS
Summary Report

Residential solid wastes are collected from many different locations, depending in large measure on the presence of suitable alleys and the amount of money available. The collection point may be at a curb, in an alley, on a porch, in a backyard, at a front or back house lot line, in a basement, or even in a house. If the pickup point is anywhere except at a curb or in an alley, a "backyard" collection system is said to be involved. This system, which is the most convenient and costly for the homeowner, is used in approximately one-third of all U.S. communities.

In a backyard system now being used by some 50 U.S. communities, residential solid wastes are collected by "satellite" vehicles. These are small, 3- or 4-wheeled vehicles that shuttle between dwelling unit storage points and a packer truck, which later takes the waste to a disposal site. They weigh 1,200 to 2,600 pounds, can hold 1 to 3 cubic yards of waste, and are equipped with hydraulic lifts for unloading into the packer truck. The vehicles reportedly produce the best results in low- to medium-density housing areas where single-family homes predominate.

Since several municipalities and private contractors had reported that the use of such vehicles had lowered costs and raised collection efficiency, this study was initiated to evaluate systems involving their employment. During the investigation, statistics were compiled on four makes of satellite vehicles (Table 1) as they operated in six geographic areas * that differed in many respects with regard to terrain, type of collection agency, and frequency of pickup. The field studies, which were conducted for 4 to 5 days in each area, covered a total of 26 satellite vehicle operators and 12 packer drivers. In all, 1,050 satellite vehicle loads and 592 packer driver trips were observed.

The data obtained were analyzed using standard statistical procedures and were subjected to extensive multiple-regression analyses. The results form the basis of the findings presented in this summary, which is intended to inform the reader in a general way about the capabilities and limitations of satellite vehicle systems.

If the reader wishes to investigate the subject further, all the data collected, the information collection procedures adopted, and the mathematical techniques employed are contained in the full report. †

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* Atlanta, Georgia; Columbia, South Carolina; Knoxville, Tennessee; Medford, Oregon; Pasadena, California; Waukesha County, Wisconsin.

† *Satellite Vehicle Systems for Solid Waste Collection; Evaluation and Application*, which can be purchased from the National Technical Information Service, Springfield, Va. 22151 (PB197 931; $3.00 for paper copy and $.95 for microfiche).

That publication advances two main theses: (1) By using the collection models developed, a community can accurately approximate the efficiency and cost of a satellite vehicle system in its area without having to resort to expensive field studies or experimental implementation. (2) It is more practical and meaningful to use annual "cost per dwelling" than the traditional "cost per ton" as a measure of relative efficiency of any collection system.

TABLE 1

SATELLITE VEHICLE SPECIFICATIONS *

Specifications	Cushman	Trashmobile	Trash Taxi	Westcoaster
Hopper capacity (cu/yd)	1.25	1.5	1.25	1.5
Loading height (in.)	50.75	48		50
Overall height (in.)	70	62		71.25
Number of wheels	3	4	3	3
Wheel size	5.00/5.70 x 8	6.00 x 14	7.00 x 13 rear 5.50/5.70 x 8 front	5.00/5.50 x 8
Wheel base (in.)	72	99.8	87	81
Engine size (hp)	18	67 at 5,200 rpm	38 at 2,500 rpm	17.6 at 3,900 rpm
Transmission	3-speed standard	4-speed standard	2-speed	3-speed standard
Vehicle weight (lbs)	1,282	2,600		1,220 (w/o cab)
Overall length (in.)	115	165		106
Overall width (in.)	45.5	62		53
Turning circle (ft)	15	20	14.5	15

* Mention of commercial products does not imply endorsement by the U.S. Government.

Daily Crew Costs

The costs associated with a satellite collection system are labor, satellite vehicle and packer truck operations and depreciation, and overhead. The costs reported varied widely because of differing economic levels, price and wage indices, and accounting methods. Total daily crew costs ranged from $79.97 to $195.62 and averaged $130.82 (Table 2).

Labor. On the average, labor costs accounted for 60 percent of the total expenses associated with a 3-man crew (two satellite operators and a packer truck driver). The latter usually received more pay and fringe benefits, and he was frequently designated crew foreman.

Satellite Vehicle Operations and Depreciation. To a great extent, operational costs are determined by the maintenance program followed and the way an operator treats his vehicle. They averaged $3.29 per vehicle per day, about 5 percent of the total expense for a 3-man crew. Most of the $3.29 went for maintenance necessitated by the lightweight construction and small engines of the vehicles. The 4-wheeled version was sturdier and needed maintenance less frequently. Fuel costs were very low; the vehicles averaged 8 miles per gallon and seldom traveled more than 20 miles in a day.

Depreciation depends on initial cost and assigned useful life. The purchase price of the 3-wheeled models ranged from $2,100 to $3,000, depending on the number bought and the optional equipment specified. The 4-wheeled vehicles cost about $3,600. Useful life, which ranged from 2 to 5 years, was influenced by the amount of abuse the vehicles received and the preventive maintenance program in force. The average depreciation per satellite vehicle per day was $3.64.

Packer Truck Operations and Depreciation. Operating costs depend primarily on the size of the chassis and the abuse it receives. The average operating cost per day was $10.33 (Table 2). Depreciation costs are determined by the same factors that apply to satellite vehicles. Initial cost varies primarily as a function of capacity. The most frequently used units could hold 18 to 20 cubic yards and cost about $15,000. Useful life ranged from 4 to 10 years. Daily depreciation averaged $12.02.

Overhead. Overhead costs were available from only one of the six collection agencies contacted, hence they were estimated to be 20 percent of all other crew costs. This figure is based on known overhead expenses incurred by communities having good accounting records.

Crew Efficiency

General. The satellite vehicles serviced an average of 5 dwelling units per load when once-a-week collection was in effect and 10 if

TABLE 2

DAILY CREW COSTS *

Study site	Cost per day						
	Two satellite vehicles		Packer truck		Labor	Overhead †	Total
	Depreciation	Operations	Depreciation	Operations	(3 men)		
Atlanta, Georgia							
(Trash Taxi)	$ 5.20	$9.22	$ 9.28	$ 5.46	$ 67.78	$19.39	$116.33
(Trashmobile)	4.62	5.28	9.28	5.46	67.78	18.54	111.26
Columbia, South Carolina	5.00	3.20	7.21	5.78	45.45	13.33	79.97
Knoxville, Tennessee	9.20	5.98	17.69	10.00	60.95	20.76	124.58
Medford, Oregon	3.52	5.60	6.15	13.76	84.82	22.77	136.62
Pasadena, California							
(Hilly)		19.08 ‡		30.90 ‡	137.91	— §	187.89
(Flat)		19.08 ‡		39.63 ‡	137.91	— §	195.62
Waukesha County, Wisconsin	11.54	7.70	14.40	9.61	72.00	23.05	138.30
Average of all sites	7.28	6.57	12.02	10.33	78.15	16.24	130.82

* Two satellite vehicles with operators and a packer truck with a driver, except in Waukesha County, Wisconsin, where the crew consisted of two men including the packer truck driver, who also operated a satellite vehicle.

† Estimated to be 20 percent of all other crew costs.

‡ Based on rental charges; not broken down into operations and depreciation.

§ Included in equipment and labor costs.

twice-a-week pickup was provided. In both cases, the operators collected an average of 15 items * per load. (Communities that allow household and yard wastes to be combined can expect the number of items collected per dwelling unit to increase by 40 to 100 percent.) On a percentage basis, total round trip time was divided as follows: collection, 84; unloading, 11; and "other," 5.

Unloading Time. Satellite vehicles have several methods of unloading that may be used in conjunction with front-, rear-, or side-loading packers (Figure 1). The four makes studied were equipped with hydraulic dumping mechanisms that had varying dump-lifting times.

Unloading time is very dependent on the packer truck's hopper capacity and duration of the compaction cycle (Table 3). Trucks with hoppers smaller than 2 cubic yards had to complete two or more compaction cycles to accommodate the wastes from one satellite vehicle load. If the latter was overloaded, the packer truck had to go through additional compaction cycles, and the operator had to make a concerted effort to minimize spillage. The packer trucks with 2- or 3-yard hoppers used in one area were able to accept wastes in an average of 1.1 minutes, while those with smaller hoppers averaged 1.6 minutes.

The amount of time the packer truck driver spends helping the satellite operators unload is also important. The drivers observed assisted from 0 to 50 percent of their time by removing waste stuck in the hopper of the satellite vehicle and cleaning the area after it was gone (Table 3). Providing assistance for 20 percent of total time on the route would be adequate for a crew with two satellite vehicles.

Queuing at the packer truck, which occurred more often than seemed necessary, increased unloading time. This could have been eliminated in the case of 2-man satellite crews if the operators had coordinated their activities. Some queuing would be unavoidable if three or more satellite vehicles were involved, but coordination would minimize delays.

Effect of Collection Frequency. On an average, it took 2.11 minutes to service the average dwelling unit on a once-a-week basis. If twice-a-week service was provided, each collection took 1.84 minutes for a total of 3.68 per week. The latter method was not, therefore, justified from an economic or efficiency viewpoint but may be warranted for health considerations.

Effect of Collection Agency. Analysis revealed that private satellite vehicle operators were 22 percent faster than their public counterparts. (Since all six agencies studied operated under the incentive system, this was eliminated as an influencing factor.)

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* Containers and other distinct and separate items of waste material.

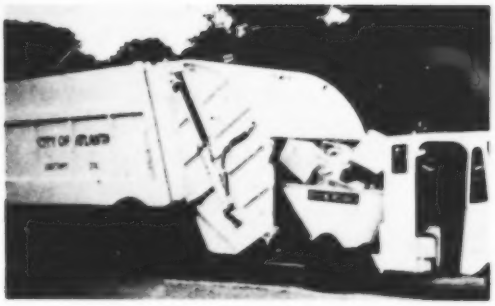

Figure 1. Satellite vehicles have several methods of unloading that may be used in conjunction with front-, rear-, or side-loading packers.

TABLE 3

SATELLITE VEHICLE UNLOADING TIME FACTORS

Study site	Satellite vehicle	Factor			
		Items per load	Packer hopper size (cu. yd.)	Packer driver assistance (% of time)	Unloading time (min.)
Atlanta, Georgia	Trash Taxi	16	1.5	7	1.5
	Trashmobile	19	1.5	7	1.2
Columbia, South Carolina	Cushman (dump)	22	*	11	2.5
	Cushman (flatbed)	19	1.5	0	2.1
Knoxville, Tennessee	Trashmobile	15	1.5	18	0.9
Medford, Oregon	Cushman	12	1.5	13	1.8
Pasadena, California	Westcoaster	10	3.0	43	1.3
	Westcoaster	10	2.0	57	0.8
Waukesha County, Wisconsin	Cushman	22	1.5	0	1.7
Average for all sites		15	1.7	16	1.5

* Side-loading packer without definite hopper capacity.

Effect of Satellite Vehicle Type. Three of the four makes studied were capable of coping with all types of route conditions. The fourth did not have enough power to climb hills and steep driveways at a reasonable speed. The expertise and collection habits of the individual operator far outweighed any slight advantage one particular vehicle might have had.

Effect of Terrain. It took about 15 percent less time to complete one load in flat areas than it did to service similar homes on extremely hilly terrain. In part, this was due to the fact that the vehicles had to travel at reduced speeds when negotiating steep driveways and roads.

Homes in extremely hilly areas were usually high-income types and sat farther from the street than houses on flat terrain; the average distance traveled up driveways was 100 feet as compared to the overall average of 80. In addition, operators in hilly areas had to walk 20 feet from their vehicles to storage locations, 10 more than on flat terrain.

Effect of Item Types Collected. Excessively heavy containers without handles required more time to carry from the storage point and unload into the satellite vehicle. When, for example, a 55-gallon drum was used instead of a standard-size container, the pickup time increased by 35 percent. Since such receptacles are cumbersome and difficult to empty, they are potentially dangerous to both the homeowner and collector. They should, therefore, be barred from use in all communities.

Less collection time was required for such miscellaneous items as paper or plastic bags and cardboard boxes, because no container had to be returned to the storage point.

Effect of Weather. Since all the studies were made in summer, the winter capabilities of the satellite vehicles could not be evaluated. The agencies reported, however, that no difficulties arose until at least two inches of snow were on the ground. It appears that ice or larger accumulations of snow could impede efficiency to the point that a walking collector would be equally or more effective.

In areas experiencing high temperatures and humidities, the satellite vehicle offers relief from fatigue and heat exhaustion by reducing the amount of walking that would otherwise be required.

Packer Truck Driver Activities. All 12 packer drivers spent less than 20 percent of their time driving, and the balance was available for collecting or helping the satellite vehicle operator (Table 4). Effectively assisting two of the latter personnel should take about 20 percent of the packer driver's time. Of the remaining 60 percent, 45 should be devoted to collection, 10 to waiting at the truck, and 5 on "other" time. Each additional crew member would require 10 percent of the driver's time, and this would correspondingly reduce his collection activities.

TABLE 4

PACKER TRUCK DRIVER ACTIVITY

Study site	Crew size	Percent of total time observed				
		Driving	Collection	Assistance	Waiting	Other
Atlanta, Georgia	3	14.7	0.3	7.0	76.3	1.7
Columbia, South Carolina	5	19.4	1.5	6.5	61.8†	10.8
Knoxville, Tennessee	3	18.1	43.3	17.1	9.2	12.3
Medford, Oregon	3	18.4	45.8	13.3	3.2	19.3
Pasadena, California	5	19.9	2.4	49.7	22.3	5.7
Waukesha County, Wisconsin *	2	5.9	87.9	2.5	0.3	3.4
Average for private agencies		14.1	59.0	11.0	4.2	11.7
Average for public agencies		18.0	1.4	21.0	53.5	6.1
Average for all sites		16.1	30.2	16.0	28.8	8.9

* Packer truck driver also drove satellite vehicle for collection.

† Drivers required to remain in trucks when on slope because of faulty emergency brakes.

All the packer truck drivers in the commercial crews did some collecting, at an average of 59 percent of the time available. The amount of time spent by municipal drivers on this activity was negligible.

Annual Cost Per Dwelling Unit

The homeowner judges the effectiveness of any residential waste collection system by the cost to him of the particular level of service he receives. As service increases, the price must go up correspondingly. Backyard service costs more than curbside, and twice-a-week pickup is more expensive than once-a-week. Within a backyard system, to collect at a house 200 feet from the street takes extra time and costs more than pickup at a similar dwelling only 100 feet back. If one house has three items to be collected and another has only two, the former will cost more to service even if all other things are equal.

The actual annual collection cost per dwelling unit for the average conditions observed in each study site ranged from $11.00 to $46.00 (Table 5). These costs cannot be compared, since they occurred under distinctively different sets of conditions. Average collection costs can be calculated only for dwelling units with identical characteristics, service levels, and crew costs.

Effects of Collection Frequency. For once-a-week collection, the average annual cost per dwelling under standard conditions was $19.00, and for twice-a-week pickup it was $28.50 (Table 6). The first method was, therefore, about 33 percent less expensive.

TABLE 5

ESTIMATED COSTS OF RESIDENTIAL SOLID WASTE COLLECTION USING SATELLITE VEHICLES, UNDER ACTUAL COMMUNITY CONDITIONS

Study site	Collection frequency per week	Cost per dwelling unit		
		Per collection	Per week	Per year
Atlanta, Georgia				
(Trash Taxi)	2	$0.32	$0.62	$33.50
(Trashmobile)	2	0.22	0.44	21.50
Columbia, South Carolina	2	0.33	0.66	31.50
Knoxville, Tennessee	1	0.20	0.20	11.00
Medford, Oregon	2	0.25	0.50	25.50
Pasadena, California				
(Hilly)	1	0.88	0.88	46.00
(Flat)	1	0.57	0.57	28.50
Waukesha County, Wisconsin	1	0.33	0.33	17.00

Effects of Collection Agency on Costs. Private collection companies averaged $15.00 per dwelling a year for once-a-week service, while public agencies averaged $23.00. The figures for twice-a-week pickup were $22.50 and $34.50, respectively (Table 6).

The 53 percent lower cost achieved by the private agencies was due solely to higher crew efficiency (dwelling units serviced per hour). This was attained because the private packer truck drivers also collected wastes and because the commercial vehicle operators were slightly faster than public operators.

Operational Recommendations

Satellite Vehicles. Equipment should be provided that facilitates transferring the waste to the packer truck with a minimum amount of spillage. Rubber or canvas flaps attached to the rear lip of the satellite's hopper and welded metal wings on the sides of the hopper at the rear can ease the flow of wastes into the packer's hopper.

A strict preventive maintenance program should be enforced to minimize mechanical failures and to extend the useful life of the vehicles. This is necessary because they are of lightweight construction and have small engines.

The vehicles should not be loaded above the top of the hopper. Overloading leads to waste being spilled while the vehicle is enroute to the packer and also extends unloading time. Driving speed should be slow enough to keep waste from blowing out of the hopper.

TABLE 6

COST ESTIMATES FOR SATELLITE VEHICLE WASTE COLLECTION SERVICE, IDENTICAL CONDITIONS BEING ASSUMED

Study site	Cost per dwelling unit per year	
	Once weekly collection	Twice weekly collection
Atlanta, Georgia		
(Trash Taxi)	$23.50	$38.50
(Trashmobile)	22.50	30.00
Columbia, South Carolina	27.00	41.00
Knoxville, Tennessee	14.50	22.50
Medford, Oregon	16.00	22.50
Pasadena, California	19.50	28.50
Waukesha County, Wisconsin	15.00	23.00
Average for all sites	19.00	28.50
Average for private agencies	15.00	22.50
Average for public agencies	23.00	34.50

Safety of the operator should be a prime consideration. Visible turning signals, large rearview mirrors, safety reflectors, and extra taillights should be standard equipment.

Packer Trucks. To realize maximum operating efficiency, it is extremely important to select an appropriate packer truck to work in conjunction with the satellite vehicles. It should have a hopper that can hold at least 2 cubic yards, thus enabling it to accommodate a satellite vehicle load in one compaction cycle. It may be necessary to make minor equipment modifications so that maximum coordination is provided between the satellite's hopper and the packer blade during unloading. This would speed up the process and minimize waste spillage.

Packer truck drivers should be able to contact their central office or garage via radio; in this way, collectors can be informed of missed or extra pickups, and vehicle downtime can be held to a minimum.

Crew Coordination. Achieving optimum efficiency depends heavily on the coordination of activities by the satellite vehicle operators and the packer truck driver. They can avoid duplication of service by establishing a set pattern that is followed each time a particular route is covered. The satellite operators should work closely enough to the packer truck to minimize haul distances and to avoid losing it. The packer truck driver should help collect wastes and unload the satellite vehicle.

Miscellaneous Information. Each satellite operator should have a 40- to 60-gallon, lightweight, manageable container to eliminate carrying the homeowner's receptacles back and forth.

Establishing good customer relations can be extremely helpful to the operators. Thoughtful residents will remove objects that obstruct access to the storage point. Placing of wastes in paper or plastic bags by the residents improves collection handling and prevents loose articles from falling out of the satellite vehicle while it is moving.

Systems Comparisons

A residential solid waste collection system should attempt to provide the most convenient, aesthetic, and sanitary service possible to the customer in the most efficient and economical manner in conformance with considerations for the health, safety, and morale of the employees. Comparing one collection system with another requires qualitative and quantitative evaluations of each of these desirable features.

Qualitative Evaluation. The most convenient waste collection service that can be provided a homeowner is pickup at the point of storage. This function can be carried out by walking collectors or personnel riding satellite collection vehicles. Observations made of both methods indicate that the satellite vehicle system provides a more sanitary service. Walking collectors tend to spill wastes at the

TABLE 7

RESIDENTIAL WASTE COLLECTION COSTS AND CREW EFFICIENCIES SATELLITE VEHICLE SYSTEM VERSUS CONVENTIONAL METHOD

Study site	Collection frequency (per week)	Crew efficiency * (Dwelling units per hour)		Annual cost per dwelling unit†	
		Satellite vehicle	Conventional (estimated)	Satellite vehicle	Conventional (estimated)
Atlanta, Georgia					
(Trash Taxi)	2	56	47	$33.50	$33.50
(Trashmobile)	2	83	65	21.50	24.00
Columbia, South Carolina	2	48	67	31.50	18.50
Knoxville, Tennessee	1	77	62	11.00	12.00
Medford, Oregon	2	113	85	25.50	30.50
Pasadena, California					
(Hilly)	1	38	36	46.00	44.50
(Flat)	1	71	45	28.50	37.50
Waukesha County, Wisconsin	1	61	50	17.00	17.00
All sites with once-a-week collection		64	51	21.50	23.50
All sites with twice-a-week collection		77	64	28.00	26.00

* For average conditions observed at each study site.
† For average conditions observed and average crew cost reported at the six study sites.

storage point because they try to minimize the number of trips they have to make to the packer truck by consolidating wastes from several containers into one receptacle. In contrast, the satellite operator merely has to dump the wastes into a 1- or 2-yard capacity hopper on his vehicle.

The use of satellite vehicles facilitates the work. For the average dwelling located 100 feet from the street, a driver walks 20 feet to a storage point, while a walking collector covers about 300 feet. As a result, the driver does not become as tired and is less likely to be injured by lifting and carrying heavy loads.

The collection agencies studied reported that employee morale rose and absenteeism fell after satellite vehicles were put into service. This was due in part to the fact that satellite vehicle operators are usually more highly regarded and compensated than walking collectors. In addition, they have shelter in inclement weather.

From the homeowner's viewpoint, the satellite vehicle represents a technological advance on the part of the collection agency, and at least some of his natural antagonism toward the waste collector is thereby eliminated. This changed attitude is bolstered by the fact that the packer truck does not make as many reverse movements as in the walking collection system, and children at play are less likely to be hurt.

There may, however, be disadvantages to the use of satellite vehicles because: (1) high winds or speeds cause waste to blow out of open hoppers; (2) many of the vehicles are excessively noisy; (3) careless operators can damage lawns, shrubbery, and flowers.

Quantitative Evaluation. The efficiencies of the two systems can be determined by comparing the total number of dwelling units each could service under identical conditions. (In this study, observed satellite efficiencies were compared with those estimated for walking crews servicing the same area.) On this basis, satellite units outperformed walking crews in five of the six study areas (Table 7).

The ultimate comparison between alternative methods of collecting residential solid wastes is the relative cost each incurs in accomplishing the same objective. Measured against the basic criterion—annual collection cost per average dwelling unit—the satellite system was found to be cheaper in four instances, equal in two, and more expensive in two. The satellite cost spectrum ranged from 24 percent less to 75 percent more than that for the walking method (Table 7).